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PART IV

# DEPARTMENT OF LABOR

## Occupational Safety and Health Administration

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# OCCUPATIONAL EXPOSURE TO BENZENE

## Emergency Temporary Standards; Hearing

Title 29—Labor

CHAPTER XVII—OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION, DEPARTMENT OF LABOR

PART 1910—OCCUPATIONAL SAFETY AND HEALTH STANDARDS

## Emergency Temporary Standard for Occupational Exposure to Benzene; Notice of Hearing

AGENCY: Occupational Safety and Health Administration, Labor.

ACTION: Emergency Temporary Standard; Notice of Hearing.

SUMMARY: This emergency temporary standard (ETS) is based on the determination that clinical and epidemiological data conclusively establish that employee exposure to benzene presents a leukemia hazard. Therefore, a grave danger currently exists for workers exposed to this cancer hazard and it is necessary to issue an emergency temporary standard to protect them. By this ETS the Occupational Safety and Health Administration (OSHA) limits employee exposure to benzene to 1 part benzene per million parts of air (1 ppm), as an 8 hour time-weighted average concentration, with a ceiling level of 5 ppm for any 15 minute period during the 8 hour day. In addition, the ETS requires the measurement of employee exposure, engineering controls, personal protective equipment and clothing, employee training, medical surveillance, work practices, and recordkeeping. The ETS will be superseded by a permanent standard within six months. A public hearing on the permanent standard will commence July 12, 1977.

EFFECTIVE DATE: May 21, 1977.

FOR FURTHER INFORMATION CONTACT:

Mr. James Foster, Office of Public Affairs, OSHA, Third Street and Constitution Avenue, N.W., Room N-3641, Washington, D.C. 20210 (202-523-8151).

SUPPLEMENTARY INFORMATION:

### Applicability of Emergency Temporary Standard

The accompanying document is an emergency temporary standard issued pursuant to sections 6(c) and 8(c) of the Occupational Safety and Health Act of 1970 (the Act) (84 Stat. 1596, 1599; 29 U.S.C. 655, 657), the Secretary of Labor's Order No. 8-76 (41 FR 25059) and 29 CFR Part 1911. The new standard, section 1910.1028, applies to all employments in all industries covered by the Act, including "general industry", construction and maritime. For reasons set out below, this standard does not apply to retail automotive service stations or to operations which use liquid mixtures containing 1 percent or less of benzene; however, these exempted operations are still subject to the requirements contained in the benzene standard at 29 CFR 1910.1000.

In addition, pursuant to section 4(b)(2) of the Act, OSHA has determined that this emergency temporary standard is more effective than corresponding standards now applicable to the maritime and construction industries and currently contained in Subpart B of Part 1910, and Parts 1915, 1916, 1917, 1918 and 1926 of Title 29, Code of Federal Regulations. Therefore, those corresponding standards are superseded by the new standard in § 1910.1028.

Pursuant to section 6(c)(3) of the Act, OSHA will shortly commence a rulemaking proceeding under section 6(b) of the Act. The emergency temporary standard will serve as a proposed final rule, along with other proposed requirements which will be published in the FEDERAL REGISTER pursuant to 29 CFR 1911.12. OSHA will publish an additional proposal in the very near future, encompassing those areas of occupational safety and health considered appropriate for the agency's permanent regulation of benzene. This document sets a public hearing on the permanent benzene standard to begin July 12, 1977.

The development of a permanent standard will be conducted pursuant to the rulemaking procedures of section 6(d) of the Act. The Assistant Secretary's decisions on the provisions of the final standard will be based on the entire record developed, including public comments and the informal rulemaking hearing.

### Events Leading to the Emergency Temporary Standard

Benzene has long been recognized as a toxin affecting the hematopoietic (blood forming) system, and a cause and effect relationship between benzene exposure and observed blood abnormalities has been established for man and animals during the last 75 years. The evidence indicating a relationship between benzene exposure and leukemia has been expanding and the international scientific community has increasingly acknowledged that worker exposure to benzene is associated with an increased risk of leukemia. Data made available by the National Institute for Occupational Safety and Health (NIOSH) in the last few weeks on workers exposed to benzene provide conclusive evidence that benzene is a leukemia causing agent and therefore immediate action to protect workers is imperative. (7)

The present OSHA standard for benzene, found in 29 CFR 1910.1000, Table Z-2, was adopted in 1971 under the authority of section 6(a) of the Act from the American National Standards Institute's (ANSI) Z 37.4-1969 standard. That OSHA standard prescribes an 8-hour time-weighted average of 10 ppm with an acceptable ceiling concentration of 25 ppm. In addition, the present standard allows excursions above the ceiling to a maximum peak concentration not to exceed 50 ppm: *Provided*, That such exposure occurs for no more than 10 minutes in any 8-hour work period. Neither the ANSI standard nor the resultant OSHA standard were based on the possible leukemia hazard from exposure to benzene.

In 1974, Aksoy et al. reported that, when contrasted with the general population, shoe workers having prior exposure to benzene had a significant increased incidence of leukemia.

Also in 1974, pursuant to section 22(d) of the Act, the Director of NIOSH submitted to the Secretary of Labor a criteria document concerning occupational exposure to benzene which stated that "the possibility that benzene can induce leukemia cannot be dismissed."(3) However, NIOSH recommended retention of the present permissible exposure limit of 10 ppm and ceiling concentration of 25 ppm as measured over a 10 minute period which recommendation was not based on benzene's potential leukemia hazard.

In a letter to the Secretary of Labor, dated April 23, 1976, the United Rubber, Cork, Linoleum, and Plastic Workers of America urged that an emergency temporary standard regulating occupational exposure to benzene be issued (42). The request was denied on May 18, 1976 by then Secretary of Labor William J. Usery (43).

Less than 1 year ago, the National Academy of Sciences, under contract with the United States Environmental Protection Agency, reviewed the literature concerning health effects of benzene exposure. (4) The Academy concluded that benzene must be considered as a suspect leukemogen.

In August 1976, NIOSH submitted to OSHA an updated criteria document which revised its earlier assessment of 1974. (5) On the basis of a review of old studies and new data, NIOSH concluded that benezene was leukemogenic. This report further pointed out that "it is apparent from the literature that benzene leukemia continues to be reported." NIOSH, therefore, recommended that, since no safe level for benzene exposure could be established "no worker be exposed to benzene in excess of 1 ppm in air". Following publication of the updated criteria document, the Director of NIOSH recommended to the Assistant Secretary of Labor, by letter dated October 27, 1976, that OSHA publish an emergency temporary standard for benzene establishing the exposure level at 1 ppm. (6) Based on the information supplied by NIOSH, OSHA issued on January 4, 1977 voluntary "Guidelines for Control of Occupational Exposure to Benzene," recommending that exposure to benzene in air not exceed an 8-hour time-weighted average of 1 ppm in any 8-hour shift of a 40 hour week. (44)

In January 1977, NIOSH informed OSHA that workplace environments had been found in St. Mary's and Akron, Ohio where a sufficient number of employees had been exposed to benzene for a number of years to facilitate an epidemiological study of health risks. (45) The worksite was a Pliofilm manufacturing plant owned by Goodyear Tire and Rubber Company. The preliminary conclusions of the epidemiological study NIOSH conducted of the pliofilm workers were transmitted to OSHA on April 15, 1977. (7) The NIOSH data demonstrated an incidence of leukemia in workers exposed to benzene that was at least five times the expected incidence. NIOSH concluded that:

The report shows a statistically significant increase in the risk for developing myelogenous leukemia among workers exposed to benzene. We hope this new information will be of assistance to you in reaching a decision on the most appropriate regulatory action.

In his letter of April 15, 1977, transmitting the report on the Goodyear Pliofilm plant, the Director of NIOSH again urged that an emergency standard be issued.

REASONS FOR ISSUANCE OF AN EMERGENCY TEMPORARY STANDARD

The Assistant Secretary finds that exposure to benzene poses a grave danger to humans. Specifically, human exposure to benzene can induce chromosomal aberrations, bone marrow damage and destruction, and other blood dyscrasias. Moreover, the accumulated studies strongly support the conclusion that benzene causes leukemia in humans. The data collected by NIOSH and made available during the past few weeks show that workers exposed to benzene in an Ohio Pliofilm plant have contracted leukemia at a rate at least five times the rate expected in the general population. Because of the conservative statistical approach to evaluating these preliminary data, final results of this study will certainly show that the increased risk of developing leukemia from exposure to benzene is even greater than five times the normal incidence of this disease. This new evidence has been interpreted by NIOSH, and is found by OSHA, to conclusively establish that benzene causes leukemia in humans. This conclusion is supported by the substantial body of clinical and epidemiological evidence previously vail- epidemiological evidence previously available which suggested the same casual relationship between benzene exposure and leukemia. In view of the new evidence the relationship can no longer be subject to serious question.

The Assistant Secretary concludes, based on a review of the latest NIOSH study and recommendations together with the epidemiological and clinical studies and other scientific data, that benzene exposure subjects workers to the risk of contracting leukemia, a malignant and irreversible disease. The best available scientific evidence indicates that no safe level for exposure to a carcinogen, including benzene, can be established or assumed to exist. OSHA has considered this question of a safe level in previous rulemaking proceedings (see preambles to carcinogen standards (39 FR 3758), vinyl chloride standard (39 FR 35892), and coke oven emissions standard (41 FR 46742)) and has relied on that considerable body of scientific opinion holding that, when dealing with a carcinogen, no safe level exists for any given population. For example, the National Cancer Institute's Ad Hoc Committee on the Evaluation of Low Levels of Environmental Chemical Carcinogens (1970) states:

No level of exposure to a chemical carcinogen should be considered toxicologically insignificant for man. For carcinogenic agents, a "safe level for man" cannot be established by application of our present knowledge. (NCI, 1970, p. 1)

And NIOSH has taken the position that in regulating cancer-causing substances "* * * it is not possible at present to determine a safe exposure level for carcinogens." (Rev. Arsenic Crit. Doc. 1975.)

Since leukemia is a form of cancer and exposures generally below 25 ppm have already induced leukemia, it is not currently possible to determine whether a safe level of exposure exists for worker populations exposed to benzene. Therefore, the Assistant Secretary has determined that exposure must be reduced to the lowest feasible level.

Furthermore, during the period of time for normal rulemaking, workers would continue to be exposed to levels higher than those that may be achieved by this ETS.

In conclusion, the Assistant Secretary determines that exposure of employees to a cancer-causing substance in the workplace environment is a "grave danger" within the meaning of section 6(c)(1)(A) of the Act. The proposition that cancer, and substances that cause cancer, pose a grave danger to man does not need lengthy discussion. The nature of a cancer hazard differs from other types of toxicity. Employees exposed to carcinogens risk incurable, irreversible and, in most cases, fatal consequences. These consequences may be irreversibly set in time. No symptomatic evidence of the development of the cancer may be apparent to the employee during a long latency period. A single exposure episode may be sufficient to cause cancer. These factors, which establish the grave danger posed by exposure to carcinogens, also lead inexorably to the conclusion that it is necessary to provide immediate protection for employees through the issuance of an emergency temporary standard, within the meaning of section 6(c)(1)(B) of the Act.

The existing 10 ppm standard, adopted from the ANSI national consensus standard, was based largely on benzene's general toxicity rather than on the leukemia hazard and, therefore, does not, within the meaning of section 6(b)(8) of the Act, provide the protection now shown to be necessary. The Assistant Secretary finds that this emergency temporary standard better effectuates the purposes of the Act than the National consensus standard.

BACKGROUND AND DISCUSSION OF EARLIER DATA

Benzene ($C_6H_6$) is a clear, colorless, non-corrosive, highly flammable liquid with a strong, rather pleasant odor. Benzene's low boiling point and high vapor pressure cause it to evaporate rapidly under ordinary atmospheric conditions, giving off vapors nearly three times heavier than air.

Benzene is produced primarily by the petrochemical and petroleum refining industries by the process called catalytic reformation, which converts certain lower octane hydrocarbons into higher octane aromatics. The two industries are responsible for 94 percent of the total U.S. production of benzene. Recovery through catalytic reformation, including the benzene formed from the hydrodealkylation of toluene, accounts for almost 80 percent of the total quantity produced. Recovery of coal-derived benzene, primarily as a by-product of the coking process in steel mills, was once the major source of benzene. Today, however, it accounts for only 6 percent of the total U.S. production.

The production of benzene is rapidly expanding with approximately 11 billion pounds produced in 1976. Only eleven other chemicals and only one other hydrocarbon (ethylene) are produced in greater tonnage in the U.S. Approximately 86 percent of this benzene is used chiefly as an intermediate in the production of other organic chemicals, including styrene, phenol, and cyclohexane. The remaining amount is used primarily in the manufacture of detergents, pesticides, solvents and paint removers. Benzene is also present as a component of motor fuels, averaging less than 2 percent in gasoline.

The first major industrial use of benzene, however, was as a solvent in the rubber industry just preceding World War I. During World War I, benzene production was stimulated greatly by the demand for and resulting production of toluene in the manufacture of explosives. The large quantities of benzene which were produced resulted in its more widespread use as a starting point for the manufacture of various organic compounds. This situation led to greatly increased uses of benzene as a solvent in the artificial leather, rubber goods, and rotogravure industries, and as a starting material in organic synthesis.

Industries and processes currently using benzene include the chemical, printing, lithograph, rubber cements, rubber fabricating, paint, varnish, stain removers, adhesives, and petroleum industries. Benzene is also used extensively in chemical laboratories as a solvent and as a reactant in numerous chemical applications. Where benzene is produced and used in large amounts, it is generally used in enclosed systems, although exposures can occur during liquid transfer operations, from equipment leakage and carryover losses, and in maintenance operations.

A. *Toxic effects.* Benzene has been recognized as a toxic substance capable of causing acute or chronic effects since 1900. Inhalation is the primary route of entry of benzene in the worker. Benzene diffuses rapidly through the lungs and is quickly absorbed into the blood. The rate of absorption is greatest during the first five minutes and thereafter declines significantly. Benzene saturation of the circulating blood may reach as high as 70–80 percent of the air content of benzene within the first 30 minutes. Relatively complete saturation of the blood may not be attained for two to three days.

Though the available literature suggests that benzene is not readily absorbed through the human skin, appreciable

quantities of benzene could be absorbed in the case of injured skin. Moreover, absorption of benzene by the skin may be significantly accelerated when benzene is present in a mixture or as a contaminant in solvents known to be readily absorbed, such as toluene and xylene. (48)

The benzene absorbed by the circulating blood is distributed throughout the body where, because of its liposolubility, it tends to accumulate in various body organs in proportion to their fat content.

Upon removal from benzene exposure, the concentration of benzene in the expired breath follows an exponential decay curve, reflecting removal of benzene from various body compartments. Elimination via this route has been estimated to range from 12 to 50 percent of the total amount of benzene absorbed in humans.

A fraction of the absorbed benzene is eliminated in an unchanged form, primarily in the expired air and, to a minimal extent, in the urine. The remainder of the absorbed benzene is metabolized by enzymes contained in the liver and ultimately to derivatives which are more water soluble thereby facilitating their removal by the kidneys. A first intermediate in the biotransformation of benzene is believed to be benzene epoxide, a highly reactive intermediate and one of several candidates suggested as the active agent responsible for benzene's myelotoxic effects. Phenol, and to a lesser extent, hydroquinone, pyrcatechol, and phenyl-mercapturic acid are the primary metabolites of benzene found in urine.

B. *Acute effects.* Exposures to high concentrations of benzene produce an almost immediate effect upon the central nervous system. Benzene concentrations of about 20,000 ppm are fatal within minutes, with death occurring from acute circulatory failure or coma, with or without convulsions. Milder exposures produce a period of nervous excitation, euphoria, headache and nausea, followed by a period of depression which can result in cardiovascular collapse and/or unconsciousness. The occurrence of nonspecific nervous disturbance as an aftereffect of acute exposures is dependent on duration of unconsciousness and/or severity of circulatory failure. Breathlessness, nervous irritability, and unsteadiness in walking have been observed to persist for a period of several weeks. Inhalation of still lower concentrations (250–500 ppm) yields signs and symptoms of mild poisoning, characterized by vertigo, drowsiness, headache, and nausea. Rapid recovery from these symptoms usually occurs following cessation of exposure.

Direct contact with the liquid may cause erythema and blistering. Prolonged or repeated skin contact, even with small quantities of benzene, has been associated with the development of a dry, scaly dermatitis or with secondary infections.

C. *Chronic effects.* Benzene exerts a primary toxic effect in the bone marrow, the major blood forming organ. Long-term exposures to low concentrations of benzene have been observed to have an initial stimulatory effect on the blood-forming tissues (bone marrow) followed by aplasia (no cell production) and fatty degeneration. Clinically an initial increase, then decrease, in the red blood cells, white blood cells, or platelets, is seen, with progression if exposures are continued, to aplastic anemia (lack of functioning of bone marrow), leucopenia (decrease in leucocytes which are white blood cells), thrombocytopenia (decrease in platelets), or pancytopenia (decrease in all cells in the peripheral blood). Secondary effects of thrombocytopenia include coagulation disturbances, characterized by increased bleeding time, poor clot retraction, and increased susceptibility to hemorrhaging. This clinical picture of chronic benzene poisoning may exist with or without the physical signs or symptoms of fatigue, vertigo, headache or excessive bleeding.

The following studies are representative, although by no means all inclusive, of the published literature on the chronic effects in humans of benzene exposure. These studies do however illustrate the diversity and variability of effects which dominate the literature on chronic benzene exposure.

1. *Blood dyscrasias.* Greenburg and coworkers' investigation in 1939 of 332 pressmen in three rotogravure printing plants was one of the earliest, comprehensive studies of benzene poisoning.(8) In addition to physical examinations, including medical and occupational histories and laboratory tests, workplace air samples and chemical analysis of ink solvents and thinners were performed in an attempt to provide a correlation with medical findings. Air samples (48) revealed benzene concentrations ranging from 11 ppm to 1060 ppm for 3 plants.

Five workers with the most severe benzene poisoning expressed no subjective complaints and physical examination revealed negative findings. The signs of "poisoning" included a reduction in the number of erythrocytes, leucocytes and platelets.

Greenburg stated that: "These findings illustrate the well-known fact that the effects of benzene may be persistent and also suggest that even before blood changes are apparent, processes may have been initiated that will continue to develop even after exposure to benzene has ceased." The authors also reported that individuals varied greatly in susceptibility although data on personal monitoring were not available.

In the same year, Mallory et al. reported post-mortem findings in 19 case studies of workers with a history of chronic exposure to benzene.(9) Exposures varied from 6 months to 12 years, but no exposure levels were available. The authors indicated that significant changes were found regularly throughout the entire hematopoietic system including bone marrow, liver, spleen and lymph nodes. Of the 19 case studies, six exhibited hypoplasia of the bone marrow (decreased bone marrow function), whereas nine cases showed hyperplasia (overactivity of the bone marrow), and two were diagnosed as leukemia. The authors concluded that exposure to benzene under varying conditions produced diverse reactions and that individual variation was of great importance.

In 1948, Hardy and Elkins investigated an artificial leather plant in Massachusetts in which a man who had been employed as a coating machine operator for 12 years died of what was diagnosed as benzene poisoning.(10) The subject had worked as a coating machine operator in other locations for 18 years. Fifty-two workers were still employed in the leather plant. Benzene concentrations ranged from 40 to 80 ppm with an average concentration of 60 ppm. Blood studies, performed upon all 52 employees, showed abnormalities in more than one blood component in sixteen of the employees. Abnormalities were observed in hemoglobin, RBC, and WBC counts. There was a wide variation among subjects as to the particular component affected. Six of the 16 employees with blood abnormalities worked in the same coating room as the deceased man. Despite this evidence of blood abnormalities from the laboratory tests, none of the physical examinations revealed any clinical signs or symptoms of overexposure to benzene.

In an epidemiological investigation, Aksoy et al compared the hematological findings of 100 healthy male subjects (controls) with those of 217 apparently healthy males, 95 percent of whom worked with solvents containing benzene in small shoe shops. (11) The shops were considered unhygienic and poorly ventilated. The concentration of benzene in the working environment ranged from 15 to 30 ppm during non-working hours to 210 ppm when adhesives containing benzene were being used. The duration of employee exposures ranged from 3 months to 17 years. In 51 (23.5 percent) of the 217 employees, hematological abnormalities were found consisting of leucopenia (9.7 percent), thrombocytopenia (1.84 percent), leucopenia associated with thromobocytopenia (4.6 percent) and pancytopenia (2.7 percent). In addition, relative to controls, benzene-exposed workers demonstrated a significant reduction in mean white cell counts and mean platelet counts. The proportion of benzene-exposed workers diagnosed with anemia was increased when compared to controls; however the presence of iron-deficiency anemia could not be ruled out.

In French survey of 45 fatal cases of benzene induced diseases of the blood, covering the years 1947 to 1962, 23 were diagnosed as leukemia and 22 were attributed to aplastic anemia. Of the latter cases, one patient was afflicted after only 2 years exposure to benzene with the remainder having an average exposure of 16 years. (13) The authors also reported that in the cases of aplastic anemia, the evolution of the illness was lengthy. A similar observation was also reported by Vigliani and Forni (1969). (14) Of 32 fatal cases of chronic benzene poisoning seen in the provinces of Milan and Pavia, 18 were due to leukemia and 14 due to aplastic anemia. These authors noted that

aplastic anemia usually occurs in patients while they are still being exposed to high concentrations of benzene. In a later study, Vigliani reported that among 59 surviving workers with benzene-related aplastic anemia, 11 later died from acute leukemia. The author also reported that he had knowledge of at least 150 cases of leukemia attributed to benzene in Italy alone. (49)

Pancytopenia has been equated with aplastic anemia, although strictly defined aplastic anemia is characterized by pancytopenia and accompanied by a fatty displacement of the bone marrow. In 1976, Vigliani and Forni stated:

> In the past two decades, the case records of patients with acute or subacute leukemia, usualy with leukopenia at some state of the illness, have become so numerous that they exceed those of acute pancytopenia. This finding led us to suspect that many cases that were considered as acute pancytopenia in the past, prior to the introduction of bone marrow biopsy, may in fact have been examples of acute hemocytoblastic leukemia leucopenic and aleukemic, or with few microhemocytoblasts in the circulating blood, possibly mistaken for lymphocytes. (15)

Unsuccessful at inducing chronic poisoning through inhalation of vapors, Sellings in 1916 produced leukopenia in rabbits through subcutaneous injections of commercially pure benzol with olive oil. (12) Selling's findings demonstrated a constant, well defined aplasia of the bone marrow, characterized by the complete disappearance of leukocytes in the peripheral blood. He noted that although both the myeloid and lymphoid tissues are vulnerable, that myeloid tissue is injured to a greater extent.

Deichman et al (1963) published results of animal studies which also indicated the great toxicity of benzene vapors for hematopoietic tissue. (16) Eight groups of rats, consisting of 40 animals per group, were exposed to benzene vapors at average concentrations of 831, 65, 61, 47, 44, 31, 29, and 15 ppm respectively. The duration of exposure was for 5 hours per day, 4 days per week, for periods ranging from 5 weeks to 7 months. Exposures to the three highest concentrations resulted in a significant leukopenia after 14 weeks. A moderate, but definite, leukopenia occurred in the rats exposed to 47 and 44 ppm after 5 to 8 weeks of exposure. Exposures to three lowest benzene concentrations for periods of 4, 3, and 7 months, respectively, induced no demonstrable changes in the numbers of leucoytes.

2. *Chromosomal aberrations.* The development of various chromosomal aberrations in peripheral leukocytes and bone marrow cells has also been attributed to benzene exposures. Several investigators characterized these aberrations as both unstable chromosome changes (i.e. including fragments, dicentric, tricentric and ring chromosomes) or stable chromosomal changes (i.e. deletions, translocations, inversions, and trisomies). These types of chromosomal aberrations also occur as the result of exposure to ionizing radiation, which is known to induce leukemia.

Increases in chromosomal aberrations in subjects suffering from benzene hemopathy were investigated by Pollini and Colombi and by Forni and Moreo. (17), (18), (19)

Forni et. al. examined chromosomal changes and their evolution in 25 individuals who had suffered bone marrow impairment of varying severity, 1–18 years previously, as a result of exposure to benzene. (20) Hematologic examinations performed at the time of the cytogenetic study, but subsequent to cessation of exposure and recovery from benzene hemopathy, indicated normal blood values. However, both stable and unstable chromosomal changes were still present. The authors noted that "This finding (persistence of chromosomal aberrations) is similar to that reported in individuals with past exposure to ionizing radiations, both therapeutic and accidental, and suggests that long-lived lymphocytes might maintain chromosome damage even for years".

Chromosomal changes in individuals either no longer exposed to benzene, or exposed intermittently to low levels, and who show no hemotological disorders, have also been investigated. After examination of three groups of factory employees who displayed no toxic symptoms, Tough et al reported that two of these groups exposed on the average of 8 and 15 years, respectively, to similar working environments containing between 25 to 150 ppm benzene, showed a significant increase of structural chromosomal aberrations in lymphocytes over the general population. (21) The third group of workers from a different kind of factory and exposed to approximately 12 ppm for an average of 13 years showed a frequency of chromosome aberrations not significantly different from those found in the general population. Tough et al suggested that their findings may indicate that an interplay between the age of workers and exposure to benzene is responsible for the observed effects.

Induction of chromosomal damage in rabbit lymphocytes by subcutaneous injection of benzene has been reported by Kissling and Speck. (22) During the phase of peripheral pancytopenia the frequency of mitotic figures showing aberrations (mostly gaps and breaks) increased from an initial value of 6 percent to 58 percent after an average of 18 weeks. Two months later, after the discontinuance of benzene treatment, visible chromosomal damage was still observed in 36 percent of the mitotic cells. Also Philip and Jensen in a preliminary report demonstrated that a single subcutaneous injection of benzene (dose: 2.0 ml benzene/kg body weight) administered to rats is capable of increasing the fraction of marrow cells which exhibit chromosomal abnormalities.(23)

3. *Leukemia.* As pointed out, benzene presents a considerable range of health risks to the working population. These include the threat of developing a form of cancer known as leukemia, a fatal and irreversible disease. Robbins defines leukemia by stating:

> Leukemia may best be considered as a neoplasm (cancer) of the white blood cells and is so classified in the "International Lists of Causes of Death." It is characterized chiefly by: the appearance of abnormal, immature white cells in the circulating blood; diffuse and almost total replacement of the bone marrow with the leukemic cells; and widespread infiltrates of the liver, spleen and other tissues, analogous to metastatic dissemination of solid tissue cancer. (24)

The recent epidemiological study of Infante et al., (51) demonstrating a five-fold increased risk of total leukemia and a ten-fold increased risk of mylomonocytic leukemia among Pliofilm workers exposed to benzene, is supported by numerous case reports in the scientific and medical literature over the past several years concerning benzene related leukemia, predominantly of the mylogenous type.

At the outset it should be noted that, prior to the development of the Infante et al. data conclusively showing the linkage between benzene exposure and the development of fatal leukemia in workers, many had argued that any substance capable of inducing bone marrow depression or other blood abnormalities should be treated as a potential leukemogen. For example, Cronkite stated over twenty years ago that:

> The heart of the problem in the induction of leukemia by industrial hazards rests upon quantitation of the agent and the yield of leukemia. Two agents used in industry have been correlated with an increased incidence of leukemia in human beings. The first, ionizing radiation, is unquestionably able to increase the incidence of leukemia. The second agent, benzol, probably can produce an increased incidence of leukemia, but the data are not as good as for the former. First, the finger of suspicion must be pointed at any agent which is able to produce an aplasia of the bone marrow, assuming it will probably be able to produce leukemia also. Second, there is no reason to doubt that any agent which will produce a cancer elsewhere in the body will not be able to produce leukemia if the offending agent is transported to the hemopoietic tissues. (25)

And, as the National Academy of Sciences pointed out in its report of June 1976:

> Benzene fits in the former category because it is well documented that it produces aplasia of the bone marrow.(4)

And as Williams et al. notes:

> Any chemical capable of producing myelotoxicity must be regarded as a potential leukemogen, if the findings in radiation—induced leukemia apply which indicate that cell damage with depression of marrow function may produce alterations leading to the transformation of damaged cells into neoplastic ones. The only chemical which has been clearly identified as one which increases the incidence of myeloid leukemias in man is benzene in rather heavy occupational exposure.(26)

The relationship between benzene exposure and leukemia in humans in the past has resulted in large part from clinical observation and to a lesser degree from epidemiological studies. The clinical evidence of leukemia has been obtained either from a survey of medical records primarily in various European

clinics, or from a canvass of the published literature reporting case histories of individuals diagnosed with leukemia. In lieu of quantitative, individual exposure data, subjective evaluations of intensity of exposure have been utilized. The epidemiological evidence has been derived from either the determination of the frequency of chronic benzene exposure among cases of leukemia or from the determination of frequency of, or mortality from, leukemia among employees of work shops that utilize benzene. In other words, in the first method the leukemia is the constant factor of all case studies and the benzene exposure is the variable; while the second method is the reverse, that is, the benzene exposure is the constant factor while leukemia is the variable.

Vigliani and Saita, in their review of 47 individuals suffering from benzene hemopathy between the period of 1942 and 1963, presented clinical and laboratory accounts of six cases, all of whom were diagnosed as having haemocytoblastic leukemia. (27) The period of exposures of these individuals to either resins, inks, varnishes, or glues containing varying concentrations of benzene ranged up to 19 years. Data on the concentrations of benzene in the workplace environment, with one exception (190–660 ppm) were not available. Although information on previous occupational histories or medical status prior to the final diagnoses were also not available, the authors stated that "attribution of the cases (of leukemia cited) to the exposure cannot be doubted." During the years 1962–1963, when there was sharp rise in the incidence of leukemia among workers exposed to benzene which coincided with an increase in number of benzene poisoning cases for this period. the risk of acute leukemia was estimated to be about 20 times greater than the risk for the general adult population.

Twelve years following the Vigliani and Saita study. Vigliani and Forni observed that in the rotogravure industry, no new cases of aplastic anemia nor of leukemia were found among workers exposed solely to toluene after this solvent was substituted for benzene in 1964. (15) However, these authors noted in 1974 that cases of benzene-induced leukemia with long latency periods may still be occasionally observed. (50) These investigators also observed that workers exposed to toluene did not exhibit chromosomal aberrations, a finding seen in employees who work with benzene.

Sixteen (16) cases of various forms of leukemia developing from long term exposure to benzene were reported by Tareef et al. (28) The duration of exposure ranged between 4 and 27 years. However, no exposure concentrations were reported. In contrast to data previously reported in Italy and Turkey, the authors found evidence of chronic leukemia. Acute leukemia accounted for only 6 of the 16 cases. Three of the six acute leukemias were diagnosed at 2, 4 and 5 years following cessation of benzene exposure. Four of the acute cases underwent a definite period of hematologic shifts ranging from anemia or leucopenia to aplastic anemia and spanning a period of 2 to 10 years. Of the 10 chronic cases reported, none of the patients had hemocytopenic changes prior to the onset of leukemia.

Aksoy et al. reported the deaths, due to leukemia, of four Turkish shoemakers resulting from their exposure to benzene for periods ranging from 6 to 14 years. (29) At the time of the study, air concentrations were found to be between 150–210 ppm of benzene. Previous occupational exposure data was not provided. Two of the four patients developed acute leukemia approximately two and three years after the occurrence of aplastic anemia although the other two did not.

Adding 8 new cases of leukemia associated with exposure to benzene to 26 previously found, between the years 1967 and 1973, Aksoy et al. observed that with the exception of one case of chronic myeloid leukemia, all had various forms of acute leukemia. (30) A preceding period of pancytopenia was reported present in almost 25 percent of the cases, and the interval between the pancytopenic period and the onset of leukemia varied from 6 months to 6 years. Often the clinical findings and blood picture improved considerably before leukemia was diagnosed. During an 8 year period of observation, the incidence of leukemia among shoe-workers chronically exposed to benzene was calculated to be more than twice that experienced by the general population (13.5/100,000 vs. 6/100,000).

Browning tabulated from published studies 61 cases of leukemia among workers exposed to benzene at various concentrations. (31) The majority of cases were of the myeloid series. Browning noted that "benezene leukemia is frequently superimposed on a condition of aplastic anemia, but can develop without a preceding peripheral blood picture characteristic of bone marrow aplasia." She also noted that the transition from aplastic anemia to leukemia was not unknown in the ideopathic forms of leukemias.

DeGowin (32) and others (Vigliani & Saita, Tareff, Aksoy etc.) observed that the development of acute leukemia in some individual cases was preceded by a latency period of up to 15 years following cessation of exposure to benzene. Some of the cases underwent what was considered to be a preleukemic period, which was characterized by leucopenia, anemia, thrombocytopenia, aplastic anemia, pancytopenia or a combination thereof. Other cases developed leukemia without any evidence of anemia. According to Vigliani and Saita, the time delay "does not permit us to attribute the disease to the persistence of benzene in the bone marrow". (27) They suggested, however, that "on the basis of the initiation-promotion theory of the induction of neoplasms, we might regard benzene as an initiator of the leukemia process, but we have no suggestion of a possible promoter."

Based on the hypothesis that the risk of leukemia was higher among workers who were exposed to benzene and medical x-rays, Ishimaru et al. conducted a retrospective epidemiological investigation examining the relationship between occupations and environmental factors, other than A-bomb exposure, and the incidence of leukemia in Nagasaki and Hiroshima between 1945 and 1967. (33) This case control study compared all cases diagnosed as definite or probable leukemias between 1945 and 1967 and residing, at the time of the onset of the disease, in Hiroshima or Nagasaki. Controls were matched for city, sex, date of birth (±30 months), distance from the atomic bomb explosion, and alive and residing in either city at the time of the onset of the disease in the patient. Four hundred ninety-two leukemia cases were identified, but matched controls could only be obtained for 413. Fifteen occupations were selected in which there had been exposure to either medical x-rays or solvents especially benzene and its derivatives. Three hundred and three adult cases with the onset of leukemia at age 15 years or over and their controls were compared. Eleven of the 15 occupations were selected based on whether there had been a history of such occupations by either the leukemia cases or the controls. Considered as a group, the risk of leukemia was found to be significantly higher (about 2.5 times greater) among those with a history of such occupations in which various volatile solvents were used as compared with those without. The relative risk was 1.8 times higher for chronic leukemia and 2.9 times higher for acute. Eighteen of the leukemia cases associated with solvents were located in distant and non-exposed radiation areas and were considered too far from the A-bomb explosion for radiation to have enhanced the increased risk. Accepting the source of error inherent in the method which was used to collect the data, the results of this study nonetheless reinforce the observation that an increase in leukemia existed in that portion of the population exposed to radiation and employed in an occupation where solvents were used, especially benzene or where exposure to medical x-ray occurred.

Thorpe, then Associate Medical Director for the Exxon Corporation, on the other hand, reported that the incidence of leukemia among a population of 38,000 workers exposed to low levels of benzene over a ten year period (1962–1972) was not significantly different when compared with the general population. (34)

This study has been severely criticized by Brown for its relaxed case-finding techniques and the methods of analyses. (35) Thus, the conclusions derived from this study must be viewed in the light of serious methodological problems which were encountered in the collection and treatment of the data. These problems, which were also acknowledged by Thorpe, included: (1) the low incidence of leukemia in the general population; (2) the validity of the diagnoses of leukemia, (3) the quantitative determina-

tions of the extent of exposures, (4) an inadequate follow-up of annuitants and (5) incomplete occupational histories on individuals diagnosed as having leukemia.

Infante et al. recently reported the results of an ongoing epidemiologic study among workers exposed to benzene during the manufacture of Pliofilm, a process unconfounded with mixed solvent exposures. (51) Although follow-up is less than 75% completed, the results already demonstrate a statistically significant excess of leukemia in benzene exposed workers as compared with the expectations based on the U.S. white male population or on a second population employed at an industry in the same state over the same period of time. Among benzene exposed workers, a five-fold excess of total leukemia and a 10-fold excess of myelomonocytic leukemias were demonstrated even under conditions leading to an underestimate of the true leukemia risk. Those conditions were the treatment and the analyses of individuals whose vital status was unknown—they were assumed to be alive until the last day of the study period. Note was made of the consistency of the types of leukemia in this study population (myelogenous and monocytic) with earlier case reports by Vigliani of workers who had died from benzene related leukemia in Italy.

The wide variety of clinical manifestations and hematological disorders observed in humans exposed to benzene, which range from simple anemia and leukopenia to aplastic anemia have been experimentally induced in animals. However, attempts to demonstrate the development of leukemia in animals exposed to benzene has met with less success. To date, a study by Lignac in 1932 is the only animal study known to OSHA in which leukemia has been observed in animals exposed to benzene. (38) Fifty-four mice (28 females, 26 males) were given subcutaneous injections of benzene (0.001 ml in 0.1 ml of olive oil) for 17 to 21 weeks. Nine mice were initially excluded following bacteriological examination and an additional 12 were lost through atrophy of various organs, especially the spleen. Lignac attributed these deaths to the size of the dose of benzene based upon the findings of a preceding experiment. Eight of the remaining 44 mice developed leukemia or Kundrat's lymphosarcoma and died 4 to 11 months after receiving the first injection. The absence of concurrent controls makes interpretation of the results difficult, and uncertainties as to the strain of the mice studied has frustrated efforts to independently confirm the findings.

More recent studies have failed to produce Lignac's results. Amiel in 1960 utilized four inbred strains of mice and subjected them to the same experimental program outlined in Lignac's study. (39) No leukemic or aplastic hemopathies were observed. More recently, Ward et al. administered benzene subcutaneously to a species and strain of mice which is responsive to leukemogenic agents. (40) Although they observed a slight increase in the percentage of granulocytic leukemias in the benzene-treated mice as compared with the controls, the authors viewed the increase as not statistically significant.

### SUMMARY AND EXPLANATION OF THE STANDARD

The requirements of the emergency temporary standard are those which OSHA considers essential and feasible to protect employees from the grave danger resulting from benzene exposure until a permanent standard can be promulgated in accordance with sections 6 (b) and (c) of the Act. The following section discusses the significant provisions of the emergency temporary standard for benzene and the necessity for including these provisions in the ETS.

A. *Scope and application.* The emergency temporary standard applies to all employers and all establishments in which benzene is present, except for two general groups. The ETS does not apply to retail automotive service stations. It's estimated that there are presently more than 200,000 such service stations in the country. Further, the limited evidence presently available suggests that employee exposures during gas dispensing operations are generally below 1 ppm. In light of these facts, and the relatively short duration of the ETS, it has been determined that exclusion of such service stations from the ETS would be appropriate.

Similarly, the ETS does not cover exposure to liquids containing benzene in amounts of 1 percent or less by volume, or benzene vapor released by these liquids. Benzene is a contaminant as well as an additive in a multitude of industrial substances. OSHA estimates that some 60,000 facilities with over 400,000 employees are engaged in industrial operations utilizing liquid mixtures containing 1 percent or less benzene by volume.

Also based on the presently available evidence in the Arthur D. Little study the exposure of employee working with these mixture is generally less than 1 ppm on an 8 hour average. In view of the foregoing, the ETS excludes users of these mixtures from its coverage.

However, during the proceedings on the proposed permanent standard, it is OSHA's intention to consider the appropriate scope and application of its permanent standards to protect workers from the leukemia hazard of benzene exposure.

Meanwhile, the existing standard in § 1910.1000 which governs benzene exposure will continue to apply to retail automotive service stations and to operations which use liquids containing one percent or less benzene.

Thus, these employers must continue to limit their employees' exposures to benzene to the 10 ppm permissible exposure limit, 25 ppm limit ceiling and 50 ppm excursion limit of that section.

The emergency temporary standard is applicable to "general industry," construction and maritime.

B. *Permissible exposure limit.* The standard has separate permissible limits for airborne exposure and for eye and dermal exposures.

(1) *Airborne exposure limits.* Considerable scientific opinion supports the regulatory policy for carcinogens that no safe level exists for any exposed population. For example, the National Cancer Institute's Ad Hoc Committee on the Evaluation of Low Levels of Environmental Chemical Carcinogens (1970) stated:

> No level of exposure to a chemical carcinogen should be considered toxicologically insignificant for man. For carcinogenic agents, a "safe level for man" cannot be established by application of our present knowledge. (NCI, 1970, p. 1).

Furthermore, NIOSH has stated that, "it is not possible at the present time to establish an exposure level at which benzene may be regarded to be without danger," a position which it has consistently taken with regard to other carcinogens.

This regulatory policy is consistent with previous OSHA actions to control employee exposure to carcinogens; see, e.g. the preambles to the carcinogen standards, 29 CFR 1910.1003 et seq. (39 FR 3758); the vinyl chloride standard, 29 CFR 1910.1017 (39 FR 35892) and the coke oven emissions standard, 29 CFR 1910.1029 (41 FR 46742). Thus, the level of 1 ppm has been chosen, not as a "safe" or "no effect" level, but on the basis of OSHA's belief, for the reasons set forth in the technical feasibility and economic impact study prepared for OSHA by Arthur D. Little Co., that 1 ppm is the lowest level that generally can be achieved at this time.

(2) *Ceiling limit.* In addition to limiting 8-hour time weighted average exposures to 1 ppm, the emergency standard requires that no employee be exposed to benzene in excess of 5 ppm averaged over any 15-minute period. An employee may be exposed to varying concentrations of benzene during the course of the workday with some periods of exposure above 1 ppm and corresponding periods below 1 ppm. OSHA has determined that the peak excursions permitted under the present standard are not appropriate in regulating exposure to benzene—a human leukemia hazard for which no safe level can be determined. For this reason, the 15-minute ceiling limit of 5 ppm is established to limit the magnitude of brief excursions which might otherwise occur even where the 8-hour time weighted average was not exceeded.

(3) *Dermal and eye exposure limits.* The standard prohibits eye and repeated or prolonged skin exposure to liquid benzene. While studies indicate benzene is not readily absorbed through intact skin, direct contact with liquid benzene can cause blistering and breakage of the skin surface. (46), (47) Under these circumstances, or where the skin is otherwise broken, prolonged or repeated skin contact may result in significant absorption of benzene. In addition, benzene absorp-

tion through the skin may be enhanced when it occurs in combination with other solvents. (48) Once absorbed, the benzene is distributed throughout the body by the blood.

C. *Notification of use.* The standard requires employers to notify OSHA of the location of workplaces in which benzene is used and to describe the conditions of use and protective measures in effect. This requirement is designed to assure compliance during the effective period of this ETS.

D. *Monitoring of exposure.* The standard requires employers to monitor each workplace where benzene is present to determine employee exposure. Such determinations may be made by monitoring and measurements which are representative of each employee's exposure to benzene over an 8-hour period. Actual measurements of airborne concentrations of benzene are required in order to determine employee exposure to benzene. However, employers do not have to measure the exposure of each individual employee.

Where the initial measurements reveal benzene exposure to be above the permissible exposure limit, monthly monitoring is required. Measurements which reveal levels of exposure to benzene below the permissible exposure limit require quarterly monitoring.

The results of the exposure measurement program determine what further action must be taken by the employer. In addition to monthly monitoring, measurement of exposures above the permissible exposure limit require the employer to institute controls to reduce the exposure to or below the permissible exposure limit. A monitoring requirement is necessary in the ETS to reduce employee exposure.

In establishing the monitoring and measurement requirements of this standard, OSHA has considered the importance of such activities to identifying exposed employees and their levels of exposure so that appropriate protective measures may be taken. OSHA has also considered the question of the feasibility of immediately complying with the monitoring requirements specified.

Performing the required measurements of employee exposure to benzene will generally involve the use of portable battery-powered air sampling pumps worn by the employee during the sampling period, charcoal tubes for absorption of the benzene, and access to appropriate laboratory facilities for subsequent analysis of the charcoal tube samples. The laboratory analysis would usually be performed using gas chromotographs, a technique commonly available in analytical laboratories and utilized for the analysis of a wide range of air contaminants found in samples of the workplace environment and general community. The standard provides that the initial sampling must be conducted and results obtained within 30 days of the effective date of the standard, which would be almost 50 days following publication of the standard. The standard does not require a separate measurement for each affected employee. It requires only that sufficient measurements are obtained to be representative of the exposure of all affected employees.

OSHA notes that the monitoring requirements will arise principally in the industries engaged in benzene production, gasoline production, and related chemical industries. These industries are generally regarded to be at the forefront of all industries with respect to existing industrial hygiene and occupational health programs. Many of the employers in these industries have extensive professional and technical staffs and established employee health programs which include periodic measurement of employee exposure to benzene. Thus these employers are expected to have little difficulty in complying with the monitoring requirements of this standard. Some of these employers have had to acquire much of the apparatus and equipment required for measuring employee exposure to benzene in order to comply with other occupational health standards previously issued by this Agency. For example, those employers engaged in manufacturing or use of vinyl chloride and polyvinyl chloride and employers engaged in the operation of coke ovens—one source of benzene production, will find that much of the effort made earlier in complying with the standards for vinyl chloride and coke oven emissions will be applicable to the requirements under this standard for measuring employee exposure to benzene.

There are approximately eight manufacturers of suitable sampling pumps. While it is not possible to know the total number of pumps immediately available from these manufacturers, one of the major manufacturers has indicated an ability to deliver 200 immediately and 800 within 45 days. That manufacturer estimated that the entire industry is capable of delivering up to 2,000 pumps in no more than 60 days from now. OSHA believes this capacity is adequate to meet the additional needs of employers who do not presently have a sufficient number of these sampling pumps. Moreover, the standard does not require that the employer own the equipment and do this monitoring himself; the utilization of consultants or contractors is another choice available to many employers.

For the above reasons, the Assistant Secretary concludes that the monitoring and measurement requirements of this emergency standard are feasible.

E. *Methods of compliance.* The standard requires employee exposure to benzene to be reduced to 1 ppm by engineering controls, work practices and respiratory protection. The emergency standard reflects a preference for the use of engineering controls, work practices and, where possible, substitution because of the greater reliability of these control techniques. (See, for example, the standards on vinyl chloride, § 1910.1017, and coke oven emissions § 1910.1029, and the reasons given therein.)

Thus, employers are required to institute feasible engineering controls and work practices as soon as possible to reduce employee exposure to or below the permissible exposure limits. In operations where engineering controls and work practices do not completely reduce exposure to the permissible level, they must still be implemented to reduce exposures to the lowest practicable level and supplemented by respirators.

OSHA recognizes that initial compliance may involve the use of respirators in many instances until engineering controls are installed and work practices initiated.

Based on a review of the Arthur D. Little Co. study and data furnished by respirator manufacturers, OSHA has determined that the availability of respirators of the required types, especially the air-purifying respirators and replacement cartridges, is adequate to meet the needs of employers who will require them for compliance with the ETS. For example, there are several manufacturers of air-purifying respirators for use against benzene. One of these manufacturers has indicated that it currently has in stock 100,000 replacement cartridges more than normal order requirements, can deliver more than 250,000 cartridges per month, and is presently increasing production capacity for this type of respirator. Additionally, OSHA is aware that respirators are currently available for use by employees in many job categories in the industries covered by this standard, such as the petroleum refining, petrochemical, chemical, and related industries.

OSHA estimates that approximately 30,000 of the 150,000 employees affected by this standard would have to be furnished respirators for use some of the time during the initial period of compliance with this standard. In view of the current existence of suitable respirators in many workplaces where they would be needed and the ability of the respirator manufacturers and suppliers to supply promptly on receipt of order additional respirators needed to comply, OSHA concludes that the respirator requirements of this standard are feasible.

F. *Medical surveillance.* The standard requires employers to institute a limited program of medical surveillance for all employees exposed to benzene. The purposes of these medical surveillance requirements are to determine the effects of exposure on the blood forming systems of the employees, to detect blood abnormalities, and to ensure that symptoms of overexposure to benzene are recognized as early as possible. The standard provides that this medical testing shall be conducted within 30 days of the effective date of the standard and quarterly thereafter. The medical surveillance requirements are limited to those minimum tests considered necessary for the emergency standard. (41) The standard also requires a medical history to be taken for every employee who may be exposed to benzene.

Facilities for performing such routine blood tests are readily available in all parts of the country and OSHA has concluded that compliance with this limited medical testing requirement is immediately feasible.

Following the medical examination, the employer must obtain a written opinion from the examining physician stating whether the employee has any medical condition that would place him at increased risk to his health from exposure to benzene. The employer must provide a copy of the physician's opinion to the affected employee. Employees are not required by the standard to submit to the medical surveillance offered under this provision.

G. *Employee education and training.* Information and training are important to protect employees from workplace cancer hazards. Appropriate training of employees can result in immediate benefits in terms of reduced exposures. To be effective, an employee education system must fully inform the employee of the specific hazards associated with the work environment. For this reason, the employer is required to inform each employee who is assigned to work in the presence of benzene about the specific operations where benzene exposure may occur and about proper procedures to avoid unnecessary exposure. The required training program must, among other things, advise employees of the signs and symptoms of exposure to benzene, the purpose of the medical tests, and the purpose, proper use, and limitation of respirators.

H. *Signs.* It is important for the protection of employees that appropriate forms of warning, as necessary, be used to inform employees of the hazards to which they are exposed in the course of their employment.

In light of the grave danger posed by exposure to benzene, OSHA believes that signs are necessary in addition to the periodic training program for informing employees of the carcinogenic hazard of benzene exposure.

I. *Recordkeeping.* The standard requires a limited amount of recordkeeping. Employers must maintain exposure measurement records and medical records. Such records must be maintained during the period of the emergency standard. Thereafter, employers will be subject to the long-term recordkeeping requirements included in the final standard promulgated under section 6 (b) of the Act.

J. *Appendixes.* Three appendixes have been attached to the standard for informational purposes. These appendixes do not impose any additional requirements on the employer.

## V.—REFERENCES

The studies and other data listed below, as well as the additional material referred to in this document, represent the principal sources upon which the emergency standard is based. A complete set of the references is available for inspection and copying at the OSHA Technical Data Center, Room S6212, U.S. Department of Labor, 3rd Street and Constitution Avenue NW., Washington, D.C. 20210.


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### VI. Environmental and Economic Impacts

The National Environmental Policy Act of 1969 (42 U.S.C. 4321 et seq.) and regulations issued thereunder (29 CFR Part 1999) require that Federal agencies assess their proposed major actions to determine whether a significant impact on the quality of the human environment may result, and if necessary to prepare an environmental impact statement. An environmental impact statement on the regulation of occupational exposure to benzene will be prepared and made available as required during the rulemaking proceedings under section 6(b) of the Act. Because of the emergency nature of this standard, no environmental impact statement can be prepared or is required for the emergency temporary standard. In addition, notice is hereby given that an economic impact analysis under Executive Order 11949 (42 FR 1017) and applicable procedures will be prepared and made available prior to the promulgation

of any permanent standard resulting from this emergency temporary standard. The preliminary economic and technological feasibility study done by Arthur D. Little indicates that the emergency standard is feasible.

### VIII—Public Participation—Notice of Hearing

Pursuant to section 6(c)(3) of the Act, this ETS as published also serves as a proposal for a permanent rule. It is OSHA's intention to develop and publish a more comprehensive proposal in the very near future which will contain additional provisions and some modifications of this emergency standard. Since the comprehensive proposal will be based on the emergency standard and since the emergency nature of the proceeding and the requirements of section 6(c) will necessitate expedited treatment throughout the development of the final standard on benzene, interested parties should begin preparation of their written comments and oral presentations immediately.

Interested persons are invited to submit written data, views and arguments with respect to this ETS and the supplementary proposal to be published shortly. These comments must be postmarked on or before June 20, 1977 and submitted in quadruplicate to the Docket Officer, Docket No. H–059, Room S6212, U.S. Department of Labor, 3rd Street and Constitution Avenue, NW., Washington, D.C. 20210. Written submissions must clearly identify the provisions of the ETS and the proposal which are addressed and the position taken with respect to each issue therein. The data, views and arguments that are submitted will be available for public inspection and copying at the above address. All timely written submissions received will be made a part of the record of this proceeding.

Pursuant to section 6(b)(3) of the Act, an opportunity to submit oral testimony concerning the issues raised by the ETS and the proposed standard, including the economic and environmental impacts, will be provided at an informal public hearing scheduled to begin at 9:30 a.m. on July 12, 1977, in the New Department of Labor Auditorium, New Department of Labor Building, 3rd Street and Constitution Avenue, NW., Washington, D.C. 20210.

#### Notices of Intention To Appear

All persons desiring to participate at the hearing, must file in quadruplicate a notice of intention to appear, postmarked on on before June 20, 1977 with the OSHA Committee Management Office, Docket No. H–059, Room N–3635, U.S. Department of Labor, 3rd Street and Constitution Avenue, NW., Washington, D.C. 20210 (telephone: (202) 523–8024).

The notices of intention to appear, which will be available for inspection and copying at the OSHA Committee Management Office, must contain the following information:

(1) The name, address, and telephone number of each person to appear;

(2) The capacity in which the person will appear;

(3) The approximate amount of time requested for the presentation;

(4) The specific issues that will be addressed;

(5) A detailed statement of the position that will be taken with respect to each issue addressed; and

(6) Whether the party intends to submit documentary evidence, and if so, a brief summary of that evidence.

#### Filing of Testimony and Evidence Before Hearing

Any party requesting more than 15 minutes for a presentation at the hearing, or who will submit documentary evidence, must provide in quadruplicate the complete text of his testimony including any documentary evidence to be presented at the hearing, to the OSHA Committee Management Office where it will be available for inspection and copying. This material must be received by July 5, 1977. Each such submission will be reviewed in light of the amount of time requested in the notice of intention to appear. In those instances where the information contained in the submission does not justify the amount of time requested, a more appropriate amount of time will be allocated and the participant will be notified of that fact.

Any party who has not substantially complied with this requirement may be limited to a 15 minute presentation, and may be requested to return for questioning at a later time.

#### Conduct of Hearings

The hearing will commence at 9:30 a.m. on July 12, 1977, with resolution of any procedural matters relating to the proceeding. The hearing will be conducted in accordance with 29 CFR Part 1911. In view of the emergency nature of this rulemaking proceeding, the hearing will be conducted in as expedited a manner as possible, consistent with a full development of the record and the rights of the parties.

The hearing will be presided over by an Administrative Law Judge who will have all the powers necessary or appropriate to conduct a full and fair informal hearing as provided in 29 CFR Part 1911. Following the close of the hearing or of any posthearing comment period, the presiding Administrative Law Judge will certify the record to the Assistant Secretary of Labor for Occupational Safety and Health. The proposal will be reviewed in light of all oral and written submissions received as part of the record, and a standard will be issued based on the entire record in this proceeding.

#### Authority

This document was prepared under the direction of Eula Bingham, Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor, 200 Constitution Avenue, NW., Room S–2315, Washington, D.C. (202–523–9261).

Accordingly, pursuant to sections 6(c) and 8(c) of the Occupational Safety and Health Act of 1970 (84 Stat. 1596, 1599, 29 U.S.C. 655, 657), the Secretary of Labor's Order No. 8–76, and 29 CFR Part 1911, Part 1910 of Title 29 of the Code of Federal Regulations is hereby amended by adding a new § 1910.1028 as set forth below. In addition, pursuant to section 4(b)(2) of the Act (84 Stat. 1592; 29 U.S.C. 653), the standard in the new § 1910.1028 is determined to be more effective than the corresponding standards now in Subpart B of Part 1910, in Parts 1915, 1916, 1917, 1918 and 1926 of Title 29, Code of Federal Regulations. Therefore, these corresponding standards are superseded by the new standard in § 1910.1028. These amendments are effective May 21, 1977.

Signed at Washington, D.C., this 29th day of April 1977.

Eula Bingham,
*Assistant Secretary of Labor.*

Part 1910 of Title 29 of the Code of Federal Regulations is therefore amended as follows:

1. A new § 1910.20 is added to 29 CFR Part 1910 to read as follows:

**§ 1910.20 Benzene.**

Section 1910.1028 shall apply to the exposure of every employee to benzene in every employment and place of employment covered by §§ 1910.12, 1910.13, 1910.14, 1910.15, or § 1910.16, in lieu of any different standard on exposure to benzene which would otherwise be applicable by virtue of any of those sections.

**§ 1910.1000 [Amended]**

2. Table Z–2 of § 1910.1000 is amended by adding a footnote 1 following the words "Benzene (Z37.4–1969)" and by adding the following below Table Z–2:

Occupational exposures to benzene are subject to the requirements of § 1910.1028 except as specifically exempted by § 1910.1028(a). Exposures exempted by § 1910.1028(a) are covered by this section.

3. Part 1910 of Title 29 of the Code of Federal Regulations is amended by adding thereto a new § 1910.1028 to read as follows:

**§ 1910.1028 Benzene.**

(a) *Scope and application.* (1) This section applies to the production, reaction, release, packaging, repackaging, storage, transportation, handling, or use of benzene.

(2) This section does not apply: (i) To retail automotive service stations; or (ii) where the exposure to benzene is only from liquid mixtures containing 1 percent or less of benzene by volume, or the vapors released from these liquids.

(b) *Definitions.* "Assistant Secretary" means the Assistant Secretary of Labor for Occupational Safety and Health, or designee.

"Benzene" ($C_6H_6$) (CAS Registry No. 000071432), means benzene, or a mixture of liquids containing benzene, or the benzene vapor released by these liquids.

"Director" means the Director, National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare, or designee.

"OSHA Area Office" means the Area Office of the Occupational Safety and Health Administration having jurisdiction over the geographic area where the employer's establishment is located.

(c) *Exposure limits.*—(1) *Permissible airborne exposure limits.* (i) The employer shall assure that no employee is exposed to an airborne concentration of benzene in excess of 1 part benzene per million parts of air (1 ppm), as an 8-hour time-weighted average.

(ii) The employer shall assure that no employee is exposed to an airborne concentration of benzene in excess of 5 ppm as averaged over any 15 minute period.

(2) *Dermal and eye exposure limit.* The employer shall assure that no employee is exposed to eye contact or repeated skin contact with benzene.

(d) *Notification of use.* Within 30 days of the effective date of this section, every employer who has a place of employment where benzene is present, shall report the following information to the nearest OSHA area office for each such establishment:

(1) The address and location of each establishment where employee exposure to benzene occurs;

(2) A brief description of each process or operation which may result in employee exposure to benzene;

(3) The number of employees engaged in each process or operation which may result in exposure to benzene and an estimate of the frequency and degree of exposure that results; and

(4) A brief description of the employee safety and health program as it relates to limitation of employee exposure to benzene.

(e) *Exposure monitoring and measurement.*—(1) *Initial monitoring.* (i) Each employer who has a place of employment where benzene is present, shall monitor each such workplace and work operation to determine the airborne concentrations of benzene to which employees may be exposed. This determination shall be made by monitoring and measurements which are representative of each employee's exposure to benzene over an 8-hour period.

(ii) Each employer, who has a place of employment in which benzene is present, shall inspect each workplace and work operation to determine if any employee may be exposed to benzene through eye contact or repeated skin contact.

(2) *Frequency of monitoring.* The monitoring required under paragraph (e) (1) of this section shall be conducted, and the results obtained, within thirty days of the effective date of this section and thereafter repeated quarterly for employees whose exposure is found to be less than 1 ppm, and monthly for those employees whose exposure is found to be in excess of the permissible exposure limit. The employer shall continue monthly measurements until at least two consecutive measurements taken at least seven (7) days apart are below the permissible exposure limit, and thereafter the employer shall measure quarterly.

(3) *Additional monitoring.* Whenever there has been a production, process, or control change which may result in new or additional exposure to benzene, or whenever the employer has any other reason to suspect a change which may result in new or additional exposures to benzene, additional monitoring which complies with paragraph (e) (1) of this section shall be made.

(4) *Employee notification.* (i) Within 5 working days after the receipt of measurement results, the employer shall notify each employee in writing of the exposure measurements which represent that employee's exposure.

(ii) Where the results reveal the employee's exposure to be over the permissible exposure limit, this notification shall also include the corrective action being taken to reduce exposure to or below the permissible exposure limit.

(5) *Accuracy of measurement.* The method of measurement shall have an accuracy, to a confidence level of 95 percent, of not less than plus or minus 25 percent for concentrations of benzene greater than or equal to 1 ppm.

(6) *Employee exposure.* For the purposes of this section, employee exposure is that exposure which would occur if the employee were not using a respirator.

(f) *Methods of compliance.* The employer shall control employee exposures to airborne concentrations of benzene to or below the permissible exposure limit, and shall protect against employee exposure to eye or repeated skin contact with benzene, by engineering controls, work practices and personal protective devices and equipment, as follows:

(1) *Engineering controls.* The employer shall develop and implement, as soon as possible, feasible engineering controls to reduce the airborne concentration of benzene to or below the permissible exposure limit.

(2) *Work practices.* The employer shall examine each work area in which benzene is present and shall institute, as soon as possible, work practices to reduce employee exposure to benzene to or below the permissible exposure limit. The work practices shall be described in writing and shall include, among other things, the following:

(i) Limiting access to work areas where benzene is present to authorized personnel only;

(ii) Prohibiting smoking and the consumption of food and beverages in work areas where benzene is present; and

(iii) Establishing good maintenance and housekeeping including the prompt cleanup of spills, repair of leaks, etc.

(3) *Respiratory projection.* Whenever engineering and work practice controls which can be instituted are not sufficient to reduce exposures to or below the permissible exposure limit, they shall be used nontheless to reduce exposurse to the lowest practicable level, and shall be supplemented by the use of respirators in accordance with paragraph (g) of this section.

(g) *Respirators.*—(1) *Required use.* The employer shall assure that respirators are used where required under this section to reduce employee exposure to or below the permissible exposure limit, and in emergencies.

(2) *Respirator selection.* (i) Where respirators are required under this section, the employer shall select and provide the appropriate respirator from Table I below and shall assure that the employee uses the respirator provided.

(ii) The employer shall select respirators from among those approved by the National Institute for Occupational Safety and Health under the provisions of 30 CFR Part 11.

TABLE I

RESPIRATORY PROTECTION FOR BENZENE

| *Concentration of benzene or condition of use* | *Respirator type* |
|---|---|
| (a) Less than or equal to 10 ppm | (1) Chemical cartridge respirator with organic vapor cartridges and half mask; or (2) Any supplied air respirator with half mask. |
| (b) Less than or equal to 50 ppm | (1) Chemical cartridge respirator with organic vapor cartridges and full facepiece; or (2) Any supplied air respirator with full facepiece; or (3) Any organic vapor gas mask; or (4) Any self-contained breathing apparatus with full facepiece. |
| (c) Less than or equal to 1,000 ppm | (1) Supplied air respirator with half mask in positive pressure mode. |
| (d) Less than or equal to 2,000 ppm | (1) Supplied air respirator with full facepiece, helmet, or hood, in positive pressure mode. |
| (e) Less than or equal to 10,000 ppm | (1) Supplied air respirator and auxillary self-contained facepiece in positive pressure mode; or (2) Open circuit self-contained breathing apparatus with full facepiece in positive pressure mode. |
| (f) Escape | (1) Any organic vapor gas mask; or (2) Any self-contained breathing apparatus with full facepiece. |

(3) *Respirator program.* The employer shall institute a respiratory protection program in accordance with § 1910.134 (b), (d), (e) and (f).

(4) Where air-purifying respirators are used (cartridge, canister or gas mask), the air-purifying canisters or cartridges shall be replaced prior to the expiration of their service life or the end of the shift in which they are first used, whichever occurs first.

(h) *Protective clothing and equipment.* Where eye or repeated skin contact with liquid benzene may occur, employers shall provide and assure that employees wear impermeable protective clothing and appropriate equipment to protect the area of the body likely to come in contact with liquid benzene.

(i) *Medical surveillance.* (1) Each employer shall make available a medical surveillance program for all employees who are or will be exposed to benzene. The medical surveillance program shall consist of:

(i) A history which includes past work exposures to benzene or any other hematologic toxins, a family history of hematological neoplasms, a history of blood dyscrasias including genetically related hemoglobin alterations, bleeding abnormalities, abnormal function of formed blood elements, a history of renal or liver dysfunction, a history of drugs routinely taken, alcoholic intake and systemic infections;

(ii) A complete blood count including a differential white blood cell count; and

(iii) Additional tests shall be conducted where, in the opinion of the examining physician, alterations in the components of the blood are related to benzene exposure.

(2) All medical procedures shall be performed by or under the supervision of a licensed physician, and shall be provided by the employer without cost to the employee.

(3) Medical surveillance and testing of each employee shall be conducted within thirty days of the effective date of this section, and quarterly thereafter. If an employee is accidently or otherwise exposed to benzene by ingestion, inhalation, skin or eye contact; or for any reason, an employee develops signs and symptoms commonly associated with exposure to benzene, the employer shall provide appropriate medical examinations and emergency treatment.

(4) *Information provided to the physician.* The employer shall provide the following information to the examining physician:

(i) A copy of this regulation and its appendixes;

(ii) A description of the affected employee's duties as they relate to the employee's exposure;

(iii) The employee's representative exposure level; and

(iv) A description of any personal protective equipment used or to be used.

(5) *Physician's written opinion.* (i) The employer shall obtain a written opinion from the examining physician which shall include:

(*a*) The results of the medical testing;

(*b*) The physician's opinion as to whether the employee has any detected medical condition which would place the employee at increased risk of material impairment of the employee's health from exposure to benzene;

(*c*) Any recommended limitations upon the employee's exposure to benzene or upon the use of protective clothing and equipment such as respirators; and

(*d*) A statement that the employee has been informed by the physician of any medical conditions which require further examination or treatment.

(ii) The employer shall instruct the physician not to reveal in the written opinion specific findings or diagnoses unrelated to occupational exposure.

(j) *Employee information and training.*—(1) *Training program.* Within fifteen days of the effective date of this section, the employer shall provide a training program for employees assigned to workplace areas where benzene is present and shall assure that each affected employee is informed of the following:

(i) The information contained in the substance data sheet for benzene which is contained in Appendix A of this section;

(ii) The quantity, location, manner of use, release or storage of benzene and the specific nature of operations which could result in exposure above the permissible exposure limit, as well as necessary protective steps;

(iii) The purpose, proper use, and limitation of respiratory devices as specified in § 1910.134;

(iv) The purpose and a description of the medical testing program required by paragraph (i) of this section and the information contained in Appendix C of this section; and

(v) The contents of this standard.

(2) *Access to training materials.* (i) The employer shall make a copy of this standard and its appendixes readily available to all affected employees.

(ii) The employer shall provide, upon request, all materials relating to the employee information and training program to the Assistant Secretary and the Director.

(k) *Signs.* (1) The employer shall post signs to clearly designate all work areas where benzene may be present, bearing the legend:

DANGER
BENZENE
CANCER HAZARD

(2) Where the permissible exposure limit is exceeded, the signs shall also include the legend: Respirator required.

(3) The employer shall assure that no statement appear on or near any required sign which contradicts or detracts from the required information.

(l) *Recordkeeping.*—(1) *Exposure measurements.* The employer shall establish and maintain an accurate record of all measurements required by paragraph (e) of this section.

(i) This record shall include:

(*a*) The dates, number, duration and results of each of the samples taken, including a description of the sampling procedure used to determine representative employee exposures;

(*b*) A description of the sampling and analytical methods used;

(*c*) Type of respiratory protective devices worn, if any; and

(*d*) Name, social security number, and job classification of the employee monitored and all other employees whose exposure the measurement is intended to represent.

(ii) This record shall be maintained during the effective period of this section.

(2) *Medical surveillance.* The employer shall establish and maintain an accurate record for each employee subject to medical surveillance as required by paragraph (i) of this section.

(i) This record shall include:

(*a*) A copy of the physician's written opinion;

(*b*) Any employee medical complaints related to exposure to benzene; and

(*c*) A copy of the information provided to the physician as required by paragraph (i) (4) of this section;

(ii) This record shall be maintained during the effective period of this section.

(3) *Availability.* (i) All records required to be maintained by this section shall be made available upon request to the Assistant Secretary and the Director for examination and copying.

(ii) Employee exposure measurement records as required by this section shall be made available for examination and copying to affected employees, and their designated representatives.

(iii) Former employees and the employees' designated representatives shall have access to such records as will indicate their own exposure to benzene.

(iv) Employee medical records required to be maintained by this section shall be made available upon request for examination and copying to a physician designated by the affected employee or former employee.

(m) *Observation of monitoring.*—(1) *Employee observation.* The employer shall provide affected employees, or their designated representatives, an opportunity to observe any measuring or monitoring of employee exposure to benzene conducted pursuant to paragraph (e) of this section.

(2) *Observation procedures.* (i) When observation of the measuring or monitoring of employee exposure to benzene requires entry into an area where the use of protective clothing and equipment or respirators is required, the employer shall provide the observer with personal protective devices required to be worn by employees working in the area, assure the use of such equipment, and require the observer to comply with all other applicable safety and health procedures.

(ii) Without interfering with the measurement, observers shall be entitled to:

(a) Receive an explanation of the measurement procedures;

(b) Observe all steps related to the measurement of airborne concentrations of benzene performed at the place of exposure; and

(c) Record the results obtained.

(n) Effective date: This section shall become effective May 21, 1977.

(o) *Appendixes.* The information contained in the appendixes is not intended, by itself, to create any additional obligations not otherwise imposed or to detract from any existing obligation.

I. SUBSTANCE IDENTIFICATION

APPENDIX A—SUBSTANCE SAFETY DATA SHEET

BENZENE

A. *Substance.* Benzene.

B. *Permissible Exposure.* Except as to retail gasoline stations and operations which use liquids containing benzene in amounts greater than 1% by volume, or the benzene vapor released by any such liquids.

1. *Airborne.* 1 part of benzene vapor per million parts of air (1 ppm); time-weighted average (TWA) for an 8-hour workday for a 40-hour week, with a ceiling concentration of 5 ppm.

2. *Dermal.* Eye contact and repeated skin contact with liquid benzene shall be prohibited.

C. *Appearance and odor.* Benzene is a clear, colorless liquid with a pleasant, sweet odor. The odor of benzene does not provide adequate warning of its harzard.

II. HEALTH HAZARD DATA

A. *Ways in which the benzene affects your health.* Benzene can affect your health if you inhale it, or if it comes in contact with your skin or eyes. Benzene may also be harmful if you happen to swallow it.

B. *Effects of overexposure.* 1. Short-term (acute) overexposure: If you are overexposed to high concentrations of benzene, well above the levels where its odors are first recognizable, you may feel breathless, irritable, euphoric, or giddy; you may experience irritation in eyes, nose, and respiratory tract. You may develop a headache, feel dizzy, nauseous, or experience unsteadiness in walking. Severe exposures may lead to convulsions.

2. Long-term (chronic) exposure: Repeated and prolonged exposure of benzene may cause headache, fatigue, exhaustion, tendency to bleed, nervousness, sleeplessness, shortness of breath, and serious blood disorders, including leukemia.

III. PROTECTIVE CLOTHING AND EQUIPMENT

A. *Respirators.* Respirators are required for those operations in which engineering controls or work practice controls are not available to reduce exposure to the permissible level. If respirators are worn, they must have a National Institute for Occupational Safety and Health (NIOSH) seal of approval. If you experience difficulty breathing while wearing a respirator, tell your employer.

B. *Protective Clothing.* You must wear impervious protective clothing (such as boots, gloves, sleeves, aprons, etc.) over any parts of your body that could be repeatedly exposed to liquid benzene.

C. *Eye and Face Protection.* You must wear splash proof safety goggles if it is possible that benzene may get into your eyes. In addition, you should wear a face shield if your face could be splashed with benzene liquid.

IV. EMERGENCY AND FIRST AID PROCEDURES

A. *Eye and face exposure.* If benzene is splashed in your eyes, wash it out immediately with large amounts of water. Call a doctor as soon as possible.

B. *Skin exposure.* If benzene is spilled on your clothing or skin, remove the contaminated clotning and wash the exposed skin with large amounts of water and soap immediately. Wash contaminated clothing before you wear it again.

C. *Breathing.* If you or any other person breathes in large amounts of benzene, get the exposed person to fresh air at once. Apply artificial respiration if breathing has stopped. Call a doctor as soon as possible.

D. *Swallowing.* If benzene has been swallowed and the patient is conscious, do not induce vomiting. Call a doctor immediately.

V. MEDICAL REQUIREMENTS

If you are exposed to benzene your employer is required to provide the following medical procedures within thirty days of the effective date of this standard, consisting of a medical history and laboratory tests. These tests shall be provided without cost to you.

VII. OBSERVATION OF MONITORING

Your employer is required to perform measurements that are representative of your exposure to benzene and you are entitled to observe the monitoring procedure. You are entitled to receive an explanation of the measurement procedure, observe the steps taken in the measurement procedure, and to record the results obtained. When the monitoring procedure is taking place in an area where respirators or personal protective clothing and equipment are required to be worn, you must also be provided with, and must wear the protective clothing and equipment.

VIII. ACCESS TO RECORDS

You or your representative are entitled to see the records of measurements of your exposure to benzene upon request to your employer. Your medical examination records can be furnished to your physician upon request to your employer.

IX. PRECAUTIONS FOR SAFE USE, HANDLING AND STORAGE

*Benzene liquid is highly flammable.* It should be stored in tightly closed containers in a cool, well ventilated area. Benzene vapor may form explosive mixtures in air. All sources of ignition must be controlled. You should use non-sparking tools when opening or closing benzene containers. You must ground or bond metal benzene containers. Fire extinguishers, where provided, must be readily available and you should know where they are located and how to operate them. Smoking is prohibited in areas where benzene is used or stored. Ask your supervisor where benzene is used on your work area and for additional plant safety rules.

APPENDIX B—SUBSTANCE TECHNICAL GUIDELINES

BENZENE

I. PHYSICAL AND CHEMICAL DATA

A. Substance Identification

1. *Synonyms.* Benzol, benzole, coal naptha, cyclohexatriene, phene, phenyl hydride, pyrobenzol. (Benzin, petroleum benzin, and benzine, do not contain benzene).

2. *Formula.* C6H6 (CAS Registry Number: 000071432)

B. Physical Data

1. Boiling point (760 mm Hg): 80.1 C (176F).

2. Specific Gravity (water=1) :0.879.

3. Vapor Density (air=1) :2.7.

4. Melting Point: 5/5 C (42F).

5. Vapor Pressure at 20 C (68F) :75 mm Hg.

6. Solubility in Water: .06%.

7. Evaporation Rate (ether=1) :2.8.

8. Appearance and Odor: Clear, colorless liquid with a distinctive sweet odor.

II. FIRE, EXPLOSION AND REACTIVITY HAZARD DATA

A. *Fire.* 1. Flash Point (closed cup): —11 C (12F).

2. Autoignition Temperature: 580 C (1076F).

3. Flammable Limits in Air, % by Volume: Lower: 1.3% Upper: 7.1%.

4. Extinguishing Media: Carbon dioxide, dry chemical, or foam.

5. Special Fire-Fighting Procedures: Do not use solid stream of water, since stream will scatter and spread fire. Water spray can be used to keep fire exposed containers cool.

6. Unusual fire and explosion hazards: Benzene is a flammable liquid. Its vapors can form explosive mixtures. All ignition sources must be controlled when benzene is used, handled, or stored. Where liquid or vapor may be released, such areas shall be considered as hazardous locations. Benzene vapors are heavier than air; thus the vapors may travel along the ground and be ignited by open flames or sparks at locations remote from the site at which benzene is handled.

7. Benzene is classified as a 1 B flammable liquid for the purpose of conforming to the requirements of 29 CFR 1910.106. A concentration exceeding 3250 ppm is considered a potential fire or explosion hazard. Locations where benzene may be present in quantities sufficient to produce explosive or ignitable mixtures are considered Class 1 Group D for the purposes of conforming to the requirement of 29 CFR 1910.309.

B. *Reactivity.* 1. Conditions contributing to instability: Heat.

2. Incompatibility: Heat and oxidizing materials.

3. Hazardous decomposition products: Toxic gases and vapors (such as carbon monoxide).

III. SPILL AND LEAK PROCEDURES

A. *Steps to be taken if the material is released or spilled.* Large amounts of water should be used to flush the spills. Do not flush benzene into confined space, such as a sewer, because of explosion danger. Remove all ignition sources. Ventilate enclosed places.

B. *Waste Disposal Method.* Disposal methods must conform to other jurisdictional regulations. If allowed, benzene may be disposed of: (a) By absorbing it in dry sand or earth and disposing in a sanitary land fill; (b) if small quantities, by removing it to a safe location from buildings or other combustible sources, pouring it in dry sand or earth and cautiously igniting it; (c) if large quantities, by atomizing it in a suitable combustion chamber.

IV. MONITORING AND MEASUREMENT PROCEDURES

A. Normal Monitoring Program: Measurements taken for the purpose of determining employee exposure are best taken such that the representive average 8-hour exposure may be determined from a single 8-hour sample or two (2) 4-hour samples. Short-time interval samples (or grab samples) may also be used to determine average exposure level if a minimum of five (5) measurements is taken in a random manner over the 8-hour work shift. Random sampling means that

any portion of the work shift has the same chance of being sampled as any other. The arithmetic average of all such random samples taken on one (1) work shift is an estimate of an employee's average level of exposure for that work shift. NIOSH recommends that samples be collected at a sampling rate of one liter per minute for a minimum of two hours. Air samples should be taken in the employee's breathing zone (air that would nearly represent that inhaled by the employee). Sampling and analysis should be performed by gas absorption tubes with subsequent chemical analysis, by gas chromatography of those areas most likely to represent the highest airborne concentration of benzene where employees are exposed. Methods meeting the prescribed accuracy and precision requirements are available in the "NIOSH Manual of Analytical Methods."

V. MISCELLANEOUS PRECAUTIONS

A. High Exposures to benzene can occur when transferring the liquid from one container to another. Such operations should be well ventilated and good work practices should be established to avoid spills.

B. Non-sparking tools should be used to open benzene containers which should be effectively grounded and bonded prior to opening and pouring.

C. Employers should advise employees of all plant areas and operations where exposure to benzene could occur. A few of the common operations in which high exposures to benzene may be encountered are: manufacture of styrene, phenol, cyclohexane, pesticides, and detergents.

APPENDIX C—MEDICAL SURVEILLANCE GUIDELINES FOR BENZENE

I. ROUTE OF ENTRY

Inhalation; possible skin absorption.

II. TOXICOLOGY

Benzene is primarily an inhalation hazard. Systemic absorption cause depression of the hematopoietic system. Inhalation of high concentrations can affect the central nervous system function. Aspiration of small amounts of liquid benzene immediately causes pulmonary edema and hemorrhage of pulmonary tissue. Skin absorption through intact skin is negligible. However, absorption will be accelerated in the case of injured skin, and benzene may be more readily absorbed if it is present in a mixture or as a contaminate in solvents which are readily absorbed. Defatting action of benzene may produce primary irritation upon repeated or prolonged contact with the skin. High concentrations are irritating to the mucous membranes of the eyes, nose, and respiratory tract.

III. SIGNS AND SYMPTOMS

Benzene is poorly absorbed through the skin, however, direct contact may cause erythema or blistering. Repeated or prolonged contact may result in drying, scaling, dermatitis, or precipitate development of secondary skin infections. Local effects of benzene vapor or liquid on the eye are slight. Only at very high concentrations is there any smarting sensation in the eye. Droplet contamination of the eye by benzene causes a moderate burning sensation, but only slight transient injury of the epithelial cell, with the eye recovering rapidly. Inhalation of high concentrations of benzene may have an initial stimulatory effect on the central nervous system characterized by exhilaration, nervous excitation, and/or giddiness, followed by a period of depression, drowsiness, fatigue, or vertigo. There may be sensation of tightness in the chest accompanied by breathlessness and ultimately the victim may lose consciousness. Convulsions and tremors occur frequently, and death may follow from respiratory paralysis or circulatory collapse in a few minutes to several hours following severe exposures. The insidious and often irreversible effect on the blood-forming system of prolonged exposure to small quantities of benzene vapor is of extreme importance. These effects have been noted to occur at concentrations of benzene which may not cause irritation of mucous membranes, or any unpleasant sensory effects. Early signs and symptoms of benzene morbidity are varied and vague, and not specific for benzene exposure. Subjective complaints of headache, dizziness, and loss of appetite may precede or procede clinical symptomology. Bleeding from the nose, gums, or mucous membranes and the development of purpuric spots may occur as the condition progresses. Rapid pulse and low blood pressure in addition to a physical appearance of anemia may accompany a subjective complaint of shortness of breath. Clinical evidence of leucopenia and anemia are the most common abnormalities reported, however, macrocytosis and thrombocytopenia are also frequently present. Bone marrow may appear normal, aplastic, or hyperplastic and may not in all situations correlate with peripheral blood findings indicating hypo-hyper-activity of blood forming tissues. There are great variations in the susceptibility to benzene morbidity which prohibits the identification of "typical" blood picture. The effects of prolonged benzene exposure may appear after several weeks or years after the actual exposure has ceased. Development of leukemia also results from exposure to benzene.

IV. TREATMENT

Remove from exposure immediately, give oxygen or artificial resuscitation if indicated. Flush eyes and wash contaminated skin. Symptoms of non-specific nervous disturbances may persist following severe exposures. Recovery from mild exposures is usually rapid and complete.

V. SURVEILLANCE AND PREVENTIVE CONSIDERATIONS

A. *Other considerations.* Benzene can cause both acute and chronic effects. It is important that the physician become familiar with the operating conditions in which exposure to benzene occurs. Those with skin disease may not tolerate the wearing of protective clothing and those with chronic respiratory disease may not tolerate the wearing of negative pressure respirators.

B. *Surveillance and screening.* Medical histories and laboratory examinations are required for each employee subject to exposure to benzene. The employer must screen employees for history of certain medical conditions (listed below) which might place the employee at increased risk from exposure.

1. *Liver disease.* The primary site of biotransformation and detoxification of benzene is the liver. Liver dysfunctions likely to inhibit the conjugation reactions will tend to promote the toxic actions of benzene. These precautions should be considered before exposing persons with impaired liver function to benzene vapors.

2. *Renal disease.* Although benzene is not known as a kidney toxin the importance of the organ in the elimination of toxic substances and metabolites justifies special consideration in those with possible impairment of renal function.

3. *Skin disease.* Benzene is a defatting agent and can cause dermatitis on prolonged exposure. Persons with preexisting skin disorders may be more susceptible to the effects of benzene.

4. *Blood dyscrasias.* Benzene is a hematopoietic depressant. Persons with existing blood disorders may be more susceptible to the effects of benzene.

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(Secs. 4, 6, 8, 84 Stat. 1593, 1599 (29 U.S.C. 653, 655, 657); Secretary of Labor's Order 8–76 (41 FR 25059); 29 CFR Part 1911.)

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